

# ROSA and Solar Cell Module Combined Environments Test Plan

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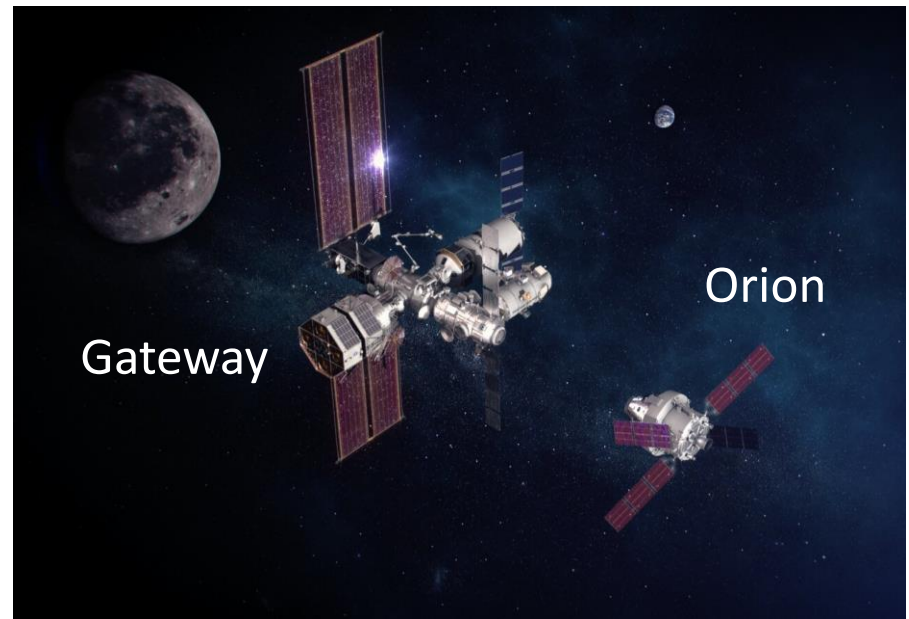
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# Background

- ❑ Maxar is developing advanced, lightweight, flexible Roll-out Solar Arrays (ROSA) for use on the Power and Propulsion Element (PPE) for Gateway
- ❑ Near Rectilinear Halo orbit (NRHO) planned for Gateway – moon centric



Credit: NASA  
iss052e002865

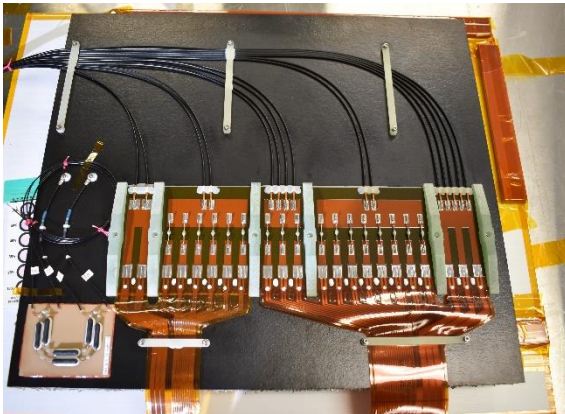


Credit: NASA/JSC 51670047958\_9323e6ad71\_h

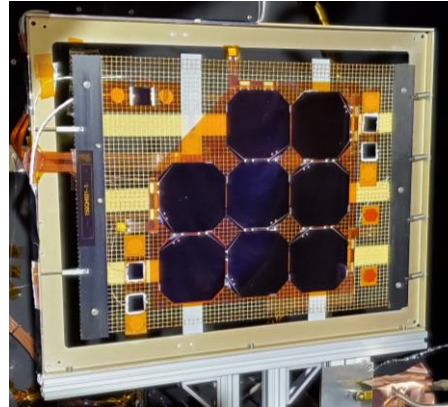
# Test Coupons

- ❑ Design risk reduction through coupon testing
- ❑ 3 solar cell module coupons:  
Z4J cells with Qioptiq CMG  
coverglass with single layer  
MgF2 anti-reflective coating
- ❑ Diode Board: representing  
electrical current management  
at base of Photovoltaic Array  
(PVA) wing

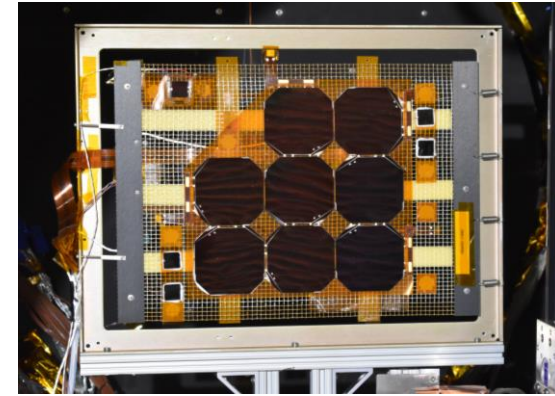
**Diode Board**



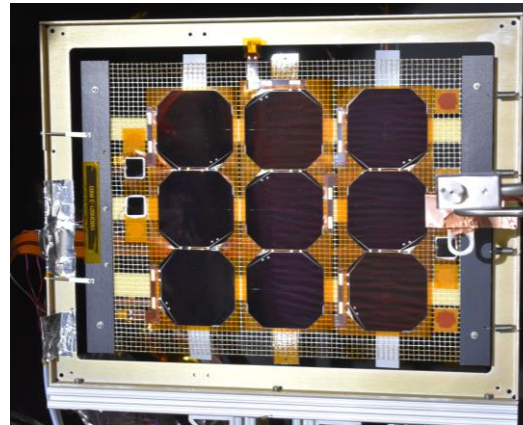
**CE-1**



**CE-2**



**CE-4**



**Back**



Picture Credits: NASA/MSFC/Todd Schneider

# Space Environments and Diagnostics

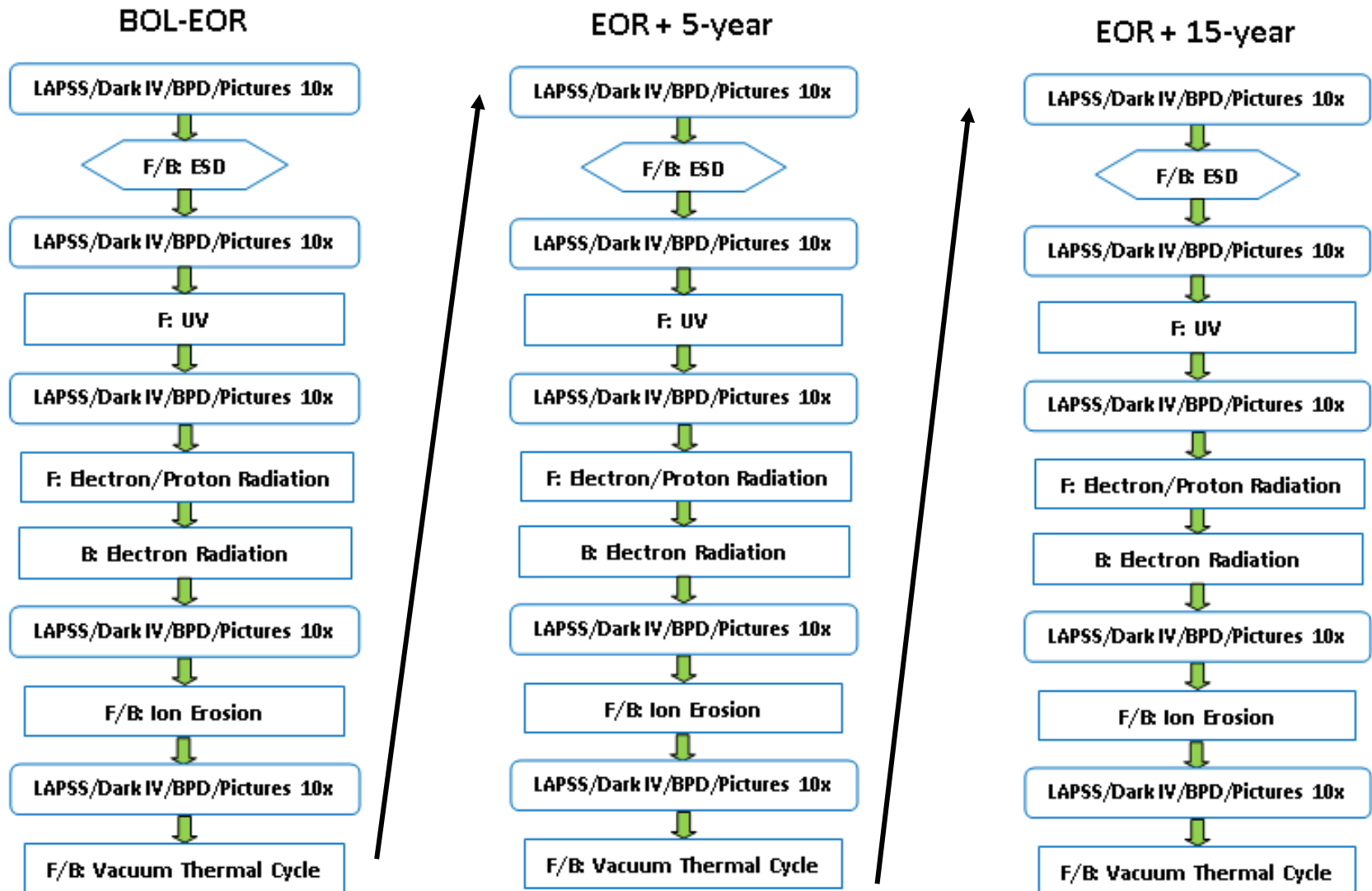
**EOR = Earth Orbit Raising**

## Cumulative Space Environment Exposure

Type	EOR	EOR+5y	EOR+15y
UV radiation in Equivalent Sun Hours (Front)	667	1333	2000
1 MeV electrons in $10^{14}$ #/cm <sup>2</sup> (Front&Back)	6.24	8.4	12.1
40-50 keV protons in $10^{15}$ #/cm <sup>2</sup> (F&B)	2.0	4.6	9.8
580 eV xenon ions in $10^{19}$ #/cm <sup>2</sup> cells (F&B)	1.35	1.4	1.5
580 eV xenon ions in $10^{18}$ #/cm <sup>2</sup> diode board (F)	8.43	8.75	9.37
vacuum thermal cycling at +100 C to -183 C (F&B)	268	318	418
electrostatic discharge (ESD) # arcs (F&B):	2	2	2

- ❑ Diagnostics are preformed at Beginning of Life (BOL) and after each environment: 10x magnification picture, Large Area Pulsed Solar Simulator (LAPSS), Dark I-V, Bypass Diode, Forward Bias (FB) and Reverse Bias (RB) of each component of diode board

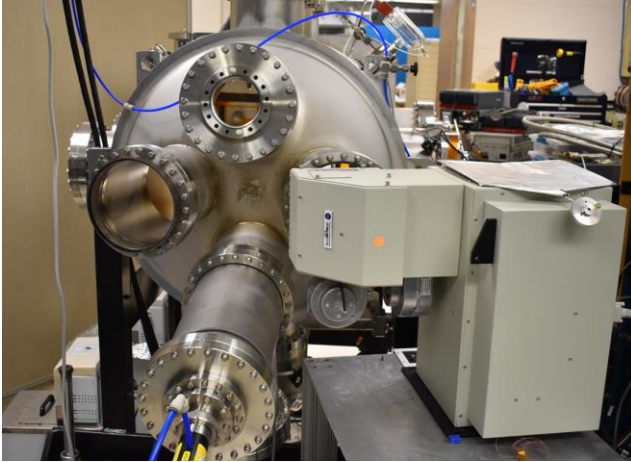
# Test and Diagnostic Sequence





# MSFC Environment Test Chambers

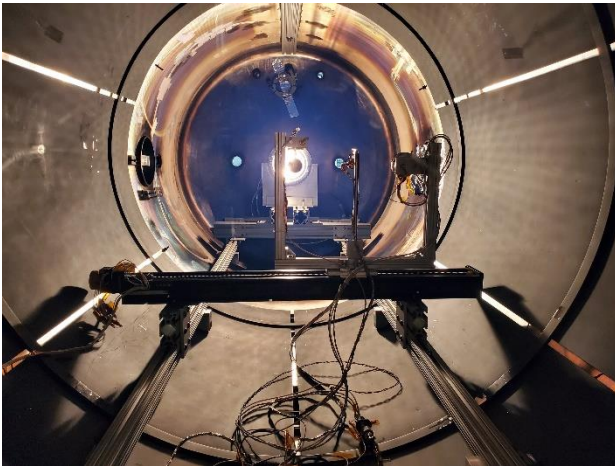
UV Test Chamber



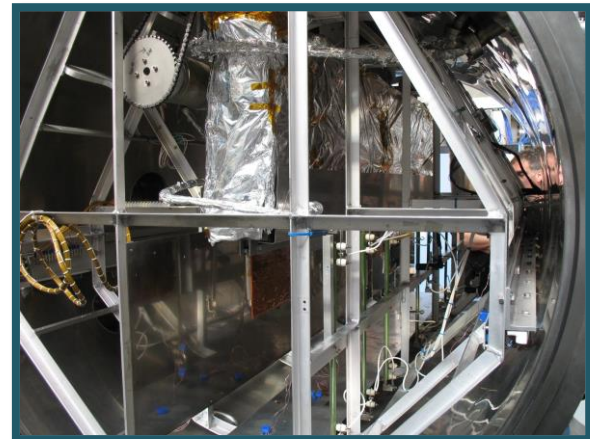
Pelletron System: Electron and Proton Radiation



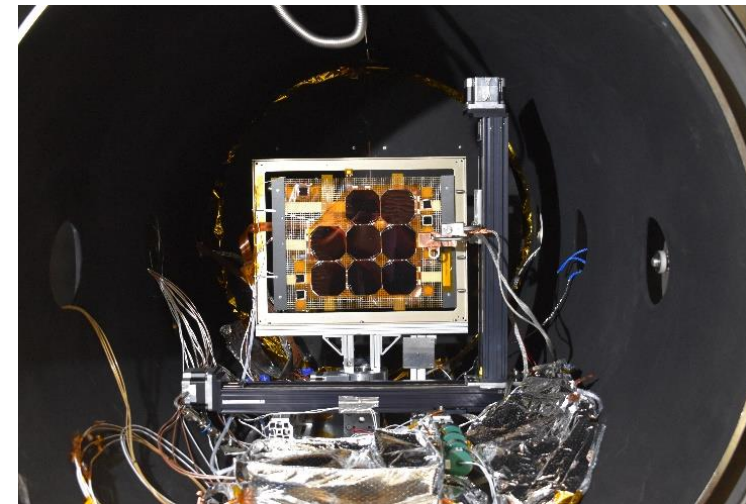
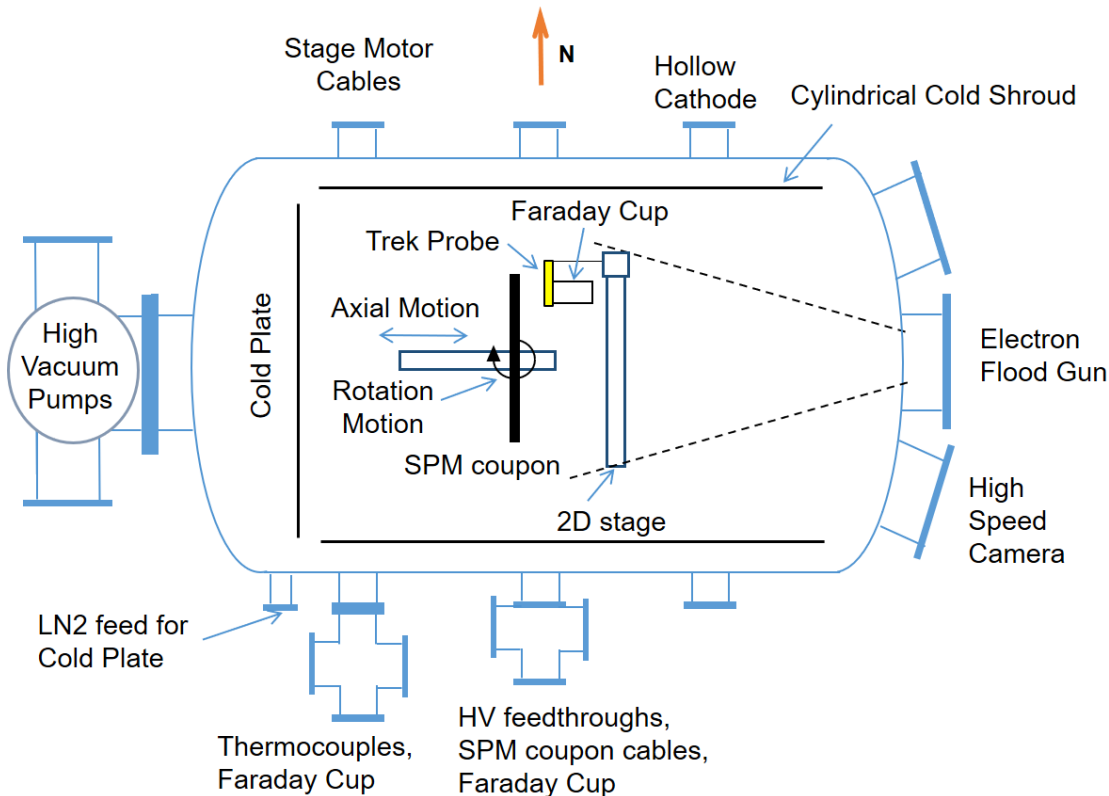
Ion Erosion Chamber: interior view



T/V chamber: interior view



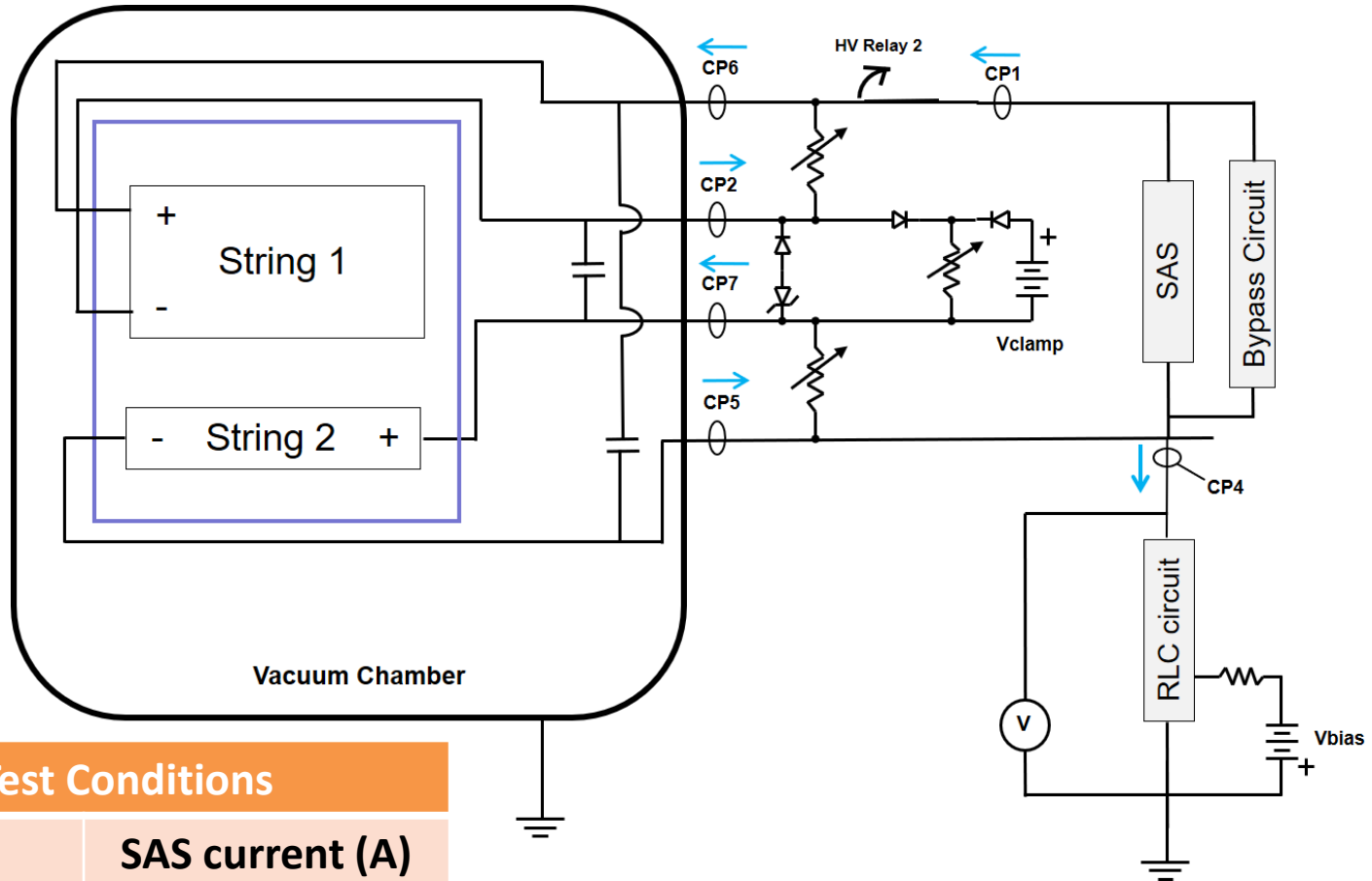
# MSFC Electrostatic Discharge (ESD) Test Chamber



Picture credit: NASA/ Todd Schneider

New chamber allows upgraded capability: (1) colder (old -65C, new -110C); (2) rotation allows front and back testing in single pumpdown; (3) Fastec high-speed camera to capture arc picture

# Solar Cell Module ESD Test Circuit



## ESD Test Conditions

String $\Delta V$	SAS current (A)
27.0	0.863
40.5	0.863
27.0	1.295

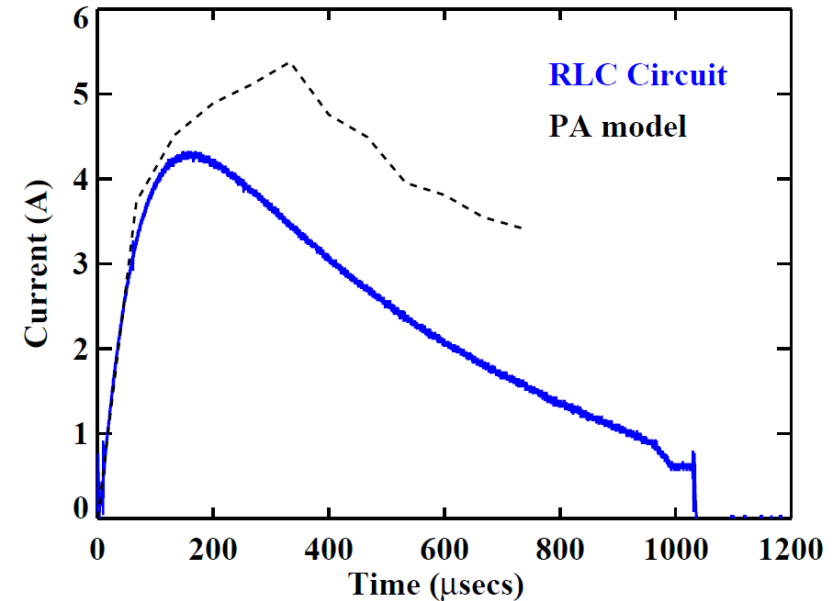
**2 arcs per ESD Test Condition  
performed after each mission phase**



# Updated Primary Arc Pulse

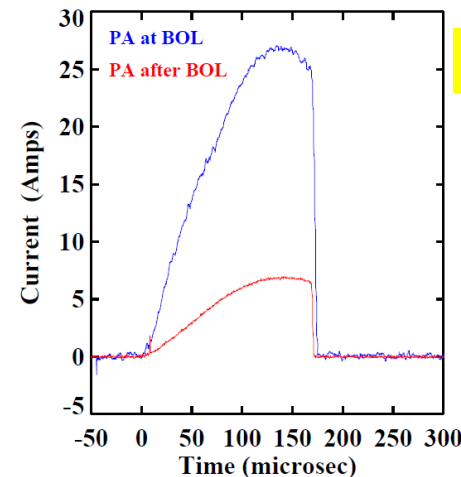
## Primary Arc (PA) pulse

- Katz et al., Multicomponent Plasma Expansion Model for Arc Discharges on Large-Area Solar Arrays, JSR, Sep 2021
- Self consistent, spherical plasma expansion
- $J_{the}$  limits arc peak current and duration



### BOL Average Arc Inception Voltage

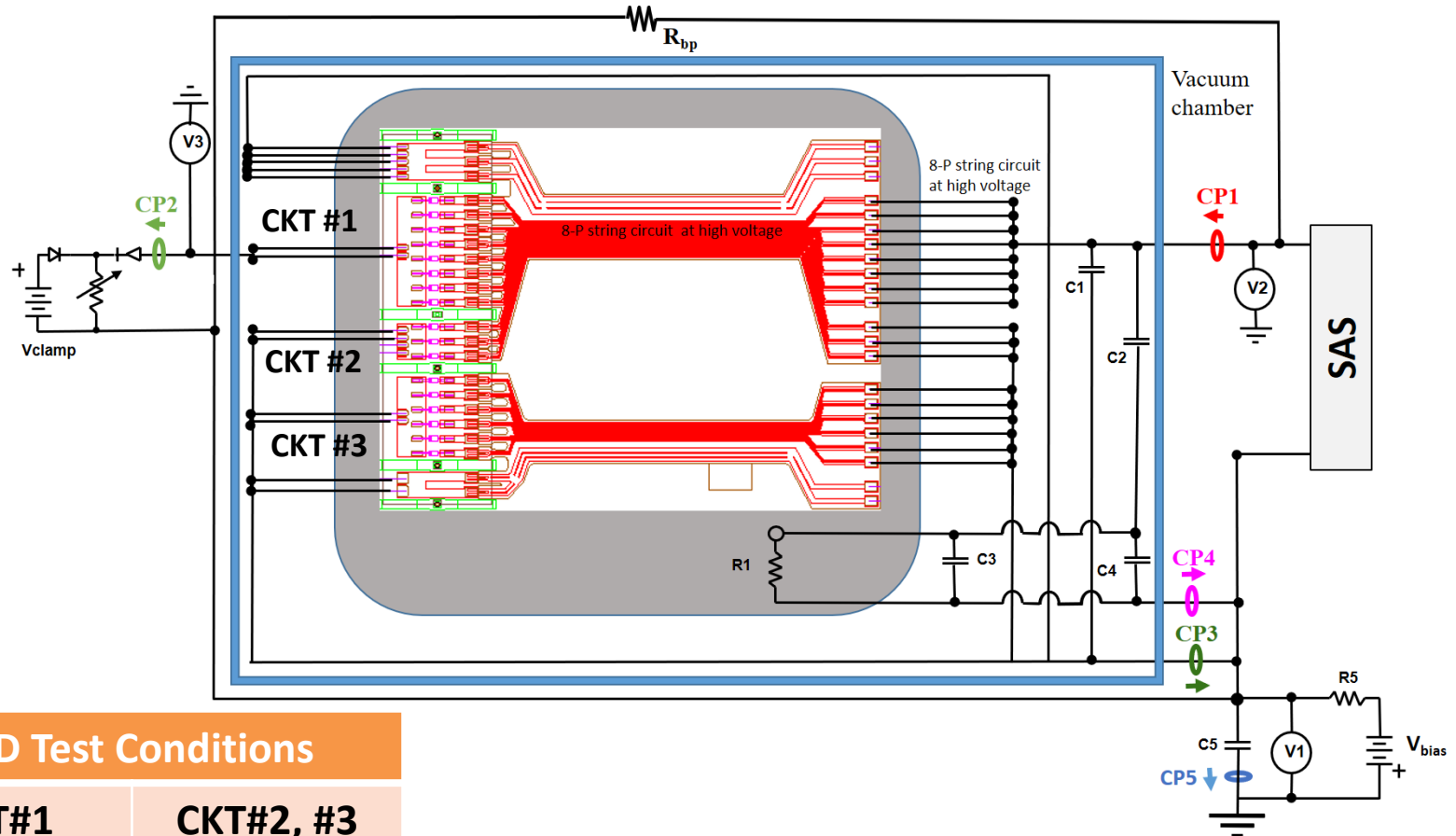
Coupon	22 C	-105 C
CE1	2.2 kV	1.9 kV
CE2	1.6 kV	1.8 kV
CE4	2.9 kV	2.3 kV



### Former PA pulse

Schneider et al. 12<sup>th</sup> SCTC, Kitakyushu, Japan, May 4-8, 2012

# Diode Board ESD Test Circuit

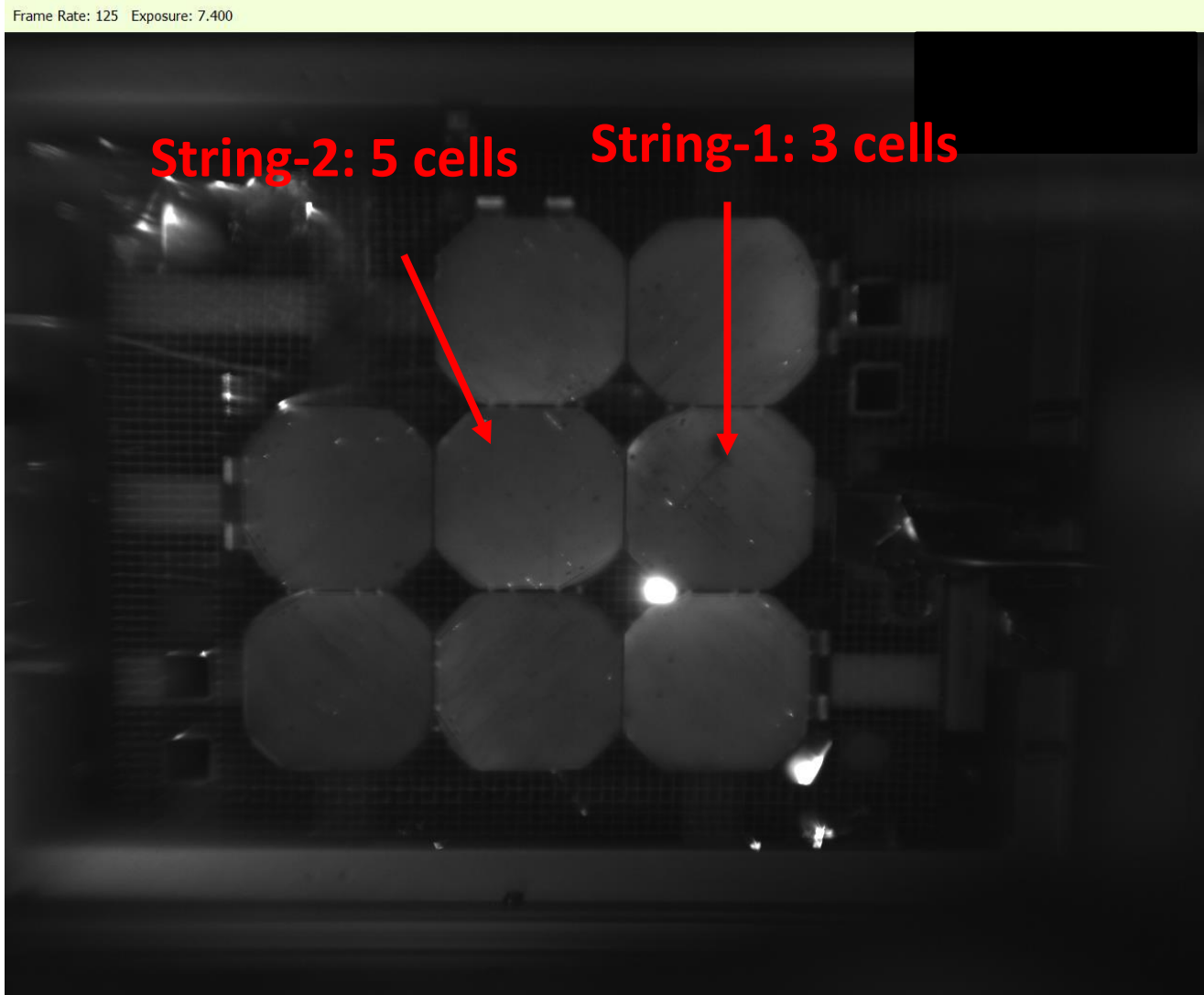


## ESD Test Conditions

CKT#1	CKT#2, #3
100V, 6.9A	0
100V, 8.3A	0
120V, 6.9A	0

**2 arcs per ESD Test Condition  
performed after each mission phase**

# CE2 BOL ESD Test: Example Arc Location

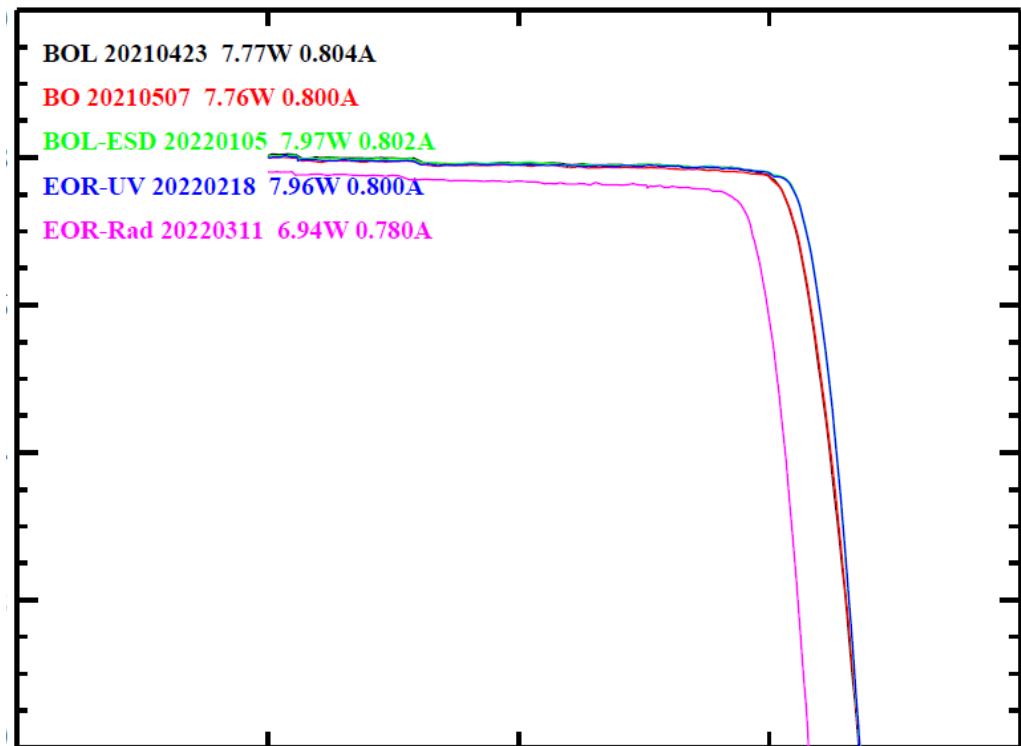


# Degradation after EOR radiation phase

## $\Delta\%$ change from BOL

String	Isc
CE1-S1	-3.1
CE1-S2	-4.1
CE2-S1	-2.4
CE2-S2	-2.4
CE4-S1	-3.0
CE4-S2	-3.0
CE4-S3	-3.2

PPE-CE4-LAPSS-S1



~ 52% of EOL cumulative electron radiation occurs in EOR  
~ 20% of EOL cumulative proton radiation occurs in EOR



# Summary

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- ❑ PPE ROSA risk reduction test campaign well underway
  - All solar cell module coupons have completed EOR radiation and are in EOR ion erosion test
  - Diode board in BOL ESD test
- ❑ Completion of test program expected ~ May 2023